OBSERVATIONS ON THE FUNCTION OF THE ETHEREAL OILS OF XEROPHYTIC PLANTS.

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It is well known that aromatic substances are widely distributed in the vegetable kingdom, for they occur in roots as well as in stems, leaves, and flowers. The scents of flowers evidently serve other purposes than those of the vegetative organs, for they act as an attraction to insects, which assist the plants in the process of pollination. Especially nocturnal insects are guided in this way to the nectar stored for them in the flowers, and it is for this reason that many flowers exhale their sweet perfumes only at night-time.

My remarks shall be confined, however, to another class of ethereal oils, viz., those occurring in the leaves of plants. They are found in almost every natural order, and in some of them their occurrence is universal. Consequently the function of these essential oils has been often discussed, although few experiments only have been made to ascertain their use.

In the earlier part of the last century these oils were often looked upon as mere waste products or excretions, which had to be removed from the body of the plant not only as useless but even as injurious to its own well-being. In modern times two views are held with regard to their function. One regards these aromatic substances as means of protection of the plants against animals, which are thereby deterred from feeding upon them. There can be no doubt that in many cases protection is obtained in this way, not only against grazing animals but especially also against the attacks by larvæ of insects, such as butterflies or moths, and the snails and slugs.

One has to distinguish, however, between plants that possess special internal reservoirs for storing the essential oil within their tissues and such which secrete them by special organs on their surface. In the former case, for which the orange and lemon, the parsley and celery, the laurel and the eucalyptus are well-known examples, there is hardly any difference of opinion with regard to the protective value of these oils, although authors, when dealing with the second group of plants, have not always been careful enough to discriminate properly between them.

Of special importance in connection with this question are the experiments on snails and slugs by Stahl.* He proved, fairly conclusively, that many plants which were not injured by snails, although the latter had no other food, were devoured by them eagerly when the essential oils had been extracted by means of alcohol or by drying. In the latter case the leaves had to be soaked in water before being offered to the snails. Stahl extended his experiments also to plants of the second group with identical results, but here his conclusions have not been accepted so generally, owing to another very ingenious explanation of the function of these oils. Plants belonging to this group are particularly numerous in the order Labiatæ; the thyme, peppermint, sage, rosemary, and our own wild dagga (*Leonotis Leonurus*, R.Br.) being familiar examples of this order.

This other theory is based upon the famous experiments of John Tyndall with regard to the influence which the vapours of essential oils have on the diathermancy of the air in which they occur. Tyndall † found that when heat-rays have to pass through such a mixture, a much larger proportion of them is absorbed than when they are passing through air alone, and that consequently an object enveloped by such a mixture of air and ethereal oil vapours would be less heated than when surrounded by air only. He filled a tube with a dried aromatic herb, such as peppermint, passed a slow current of air through the tube and examined this mixture of air and vapour in another tube with regard to its permeability for heat-rays. He found that air with the vapour of lavender gave an absorption of heat 32 times as great as that of air alone, thyme 33, peppermint 34, and wormwood 41 times.

When he employed the essential oils instead of the herbs by placing bibulous paper saturated with the oil into his first tube, he obtained much larger figures, for lavender oil gave 60, thyme 74, and oil of aniseed even 372.

When these observations became known to biologists, they

* Stahl, E., "Pflanzen und Schnecken," Jena, 1888.

† Tyndall, John, "Heat Considered as a Mode of Motion," London, 1863, p. 360.

thought that they had found an excellent explanation of the very common and general occurrence of aromatic plants in dry climates. It is a well-known fact that many plants of desert regions are strongly scented, agreeably or not with regard to our own olfactory organs as the case may be. It was thought that these plants, by surrounding themselves with an atmosphere of aromatic vapour, were able to guard off a portion of the heat of the sun's rays and that in this way their transpiration would be kept down considerably.

It must not be thought that the expression of this view is of isolated occurrence. On the contrary, several of our foremost biologists and phyto-geographers have accepted it. Haberlandt, in his "Physiological Anatomy of Plants," looks upon Tyndall's experiments as quite conclusive; Volkens, Drude, Warming, and others share his views, and MacMillan,* in "Minnesota Plant-life," adopts the same, as the following passage will show: "Many desert plants we know by their pungent odour, *e.g.*, wormwoods and sage-bushes. It has been shown that the vapour of the ethereal oils existing in such plants, when commingled with the atmosphere, reduces its permeability to heat, and thus the constant exhalation of perfume from the body of a wormwood is to be regarded as a device for tempering the heat of the sun."

On the other hand I must not omit to state that, as far as I have been able to ascertain, Tyndall himself never interpreted his results in this way, and that consequently the designation of this hypothesis as "Tyndall's theory" places the responsibility on the wrong person.

Some authors, however, did not accept this explanation, although, of course, it would have been very difficult to disprove it. Recently, Detto,† a pupil of Stahl, has repeated the experiments with snails and slugs in various ways, and has arrived at the conclusion that the function of these oils of exogenous or superficial origin is the same as that of the internally stored oils, *i.e.*, that they are means of protection of the plants against injuries by animals. "I do not think that this property of essential oils (viz., their diathermancy) is of greater importance to the life of the plant as, *e.g.*, their colour, their density, or their action on the polarised light."

I may say that I have arrived at the same conclusion, principally on account of observations made during the last twenty years in various parts of South Africa.

* MacMillan, "Minnesota Plant-life," Report of the Survey, 1899, p. 467.

† Detto, Carl, "Ueber die Bedeutung der ätherischen Oele bei Xerophyten," München, 1903.

If the production of a diathermanic atmosphere around the plants would be the principal function of the ethereal oils, one should expect that the intensity of secretion would be largest during the hottest part of the day and the driest season of the year. That is, however, not the case in South Africa, neither in the Karroo nor in the South-Western region. On the contrary, a considerable number of plants, although very aromatic, emit hardly any scent under these conditions, but are bathed in odour during damp or foggy weather, even when dripping wet.

This behaviour of plants of both groups, *i.e.*, such with internal as well as with external organs of secretion, is, I think, fatal to the "diathermanic" theory, for how could we assume that substances which are produced by specially constructed and highly diversified organs should be so universally destined to be wasted!

The following plants have been observed by me to exhale their scent when the atmosphere is moist, but do not do so during dry weather:—

Coleonema album B. et W., *Diosma vulgaris* Schlecht., and many species of *Agathosma*—in fact, most Rutaceæ. The scent of Coleonema in misty weather is so strong that one notices its neighbourhood even yards away from it. Haberlandt has shown that the oil cavities of some plants of this order possess a specially constructed lid, which is thrown off, thus allowing the oil to escape, when the leaf is strained in any way, *e.g.*, when touched by an animal. I have noticed that the turgor of the leaf due to a plentiful supply of moisture at a time when there is no transpiration produces to some extent the same effect.

Another common plant of our hills and mountains behaves in a similar way—that is *Bubon Galbanum* L., the wild celery, also called the blistering bush. The leaves contain a highly volatile essential oil, but there is usually no scent about the bush, and our mountaineers did not know for many years that this was the culprit which produced the blisters on their hands, for the effect shows itself only a day or two after one has touched the bush. The virulence varies considerably, for sometimes one may handle a bunch of the plant unpunished, and at others a slight touch will do the blistering. The explanation is simple when once known. In dry weather one has to crush the leaves in order to obtain any effect, and even then I have sometimes failed when experimenting with it, but in damp weather the oil vessels burst at the slightest touch or movement of the bush, hence its fairly strong smell at such a time.

Even the common rhenoster bush, *Elytropappus rhinocerotis*

Less., is highly aromatic in damp weather, and its scent will then accompany you for many miles when travelling in the country. Other plants are *Elytropappus glandulosus* Less., *Relhania genistæfolia* L'Her., the so-called pepperbush of the Ruggens; *Osteospermum ilicifolium* L., of the mountain region, and the gland-covered, sticky *O. spinosum* L., of the hills; *Artemisia afra* Jacq., the Cape wormwood; many species of Pelargonium; *Malvastrum capense* G. et H., and even a dweller of the woods, *Plectranthus fruticosus* Lamk.

All these observations, incomprehensible if the hypothesis on the diathermanic function of the oils be accepted, are, however, in perfect accordance with the view that the oils act as a deterrent to animal enemies, and in particular to those which are to be feared especially in damp weather, viz., snails and slugs. It may be objected that there are no snails or slugs in the veld or on the mountains, as only some of the introduced species have become common in the gardens of the Cape. That is an error. I have found snails as well as slugs on various mountains of the South-West and also in karroid spots, *e.g.*, near Clanwilliam. One must, of course, not expect to see them on a dry summer's day. But when the South-East cloud covers the mountain for days, or when a nice drizzling rain is falling, you are fairly sure to find some, provided that you feel inclined to look for them. In fact, one of the introduced species from the Mediterranean, *Limax Gagates*, a black slug which is about three inches long, is so common in the upper part of the Platteklip gorge, that on such an occasion one may gather a dozen in a few minutes on the rocks near the top of the mountain. I have also collected an indigenous species of slugs (*Oopeltes*) and several kinds of snails (*Dorcasia*, *Natalia*, and *Phasis*) on the Winterhoek near Tulbagh and on the Zwartebergen, and I learn from Mr. Lightfoot that there are a fair number of indigenous species of slugs and snails at the Cape, although few of them only are occasionally common.

In conclusion I may add, that in many cases the protection against grazing animals obtained by means of these oils will be of more importance to the plants than that against snails or caterpillars, but that the little foes would probably rapidly multiply and endanger the existence of many plants if they were not guarded off in such an effective way.